THE PRINCIPAL ASPECTS OF THE LIMNIOLOGICAL REGIME OF KARAVASTA LAGOON SYSTEM

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Abstract

Karavasta Lagoon system together with Shkumbini and Semani River mouths form a most complicated and dynamic coastal area of the Adriatic Sea. It is of an enormousand international importance for its natural individuality and biodiversity. Terbufi and Myzeqe drainage channels are important components of this area.

In this paper it is attempted to present a general evaluation of the principal aspects of the limniological regime of Karavasta lagoon systems: level, water balance, physicochemical parameters etc.

The geological structure and the hydromorphology of deltaic coastal of the Karavasta system are the principal components of this paper.

The geological and hydrological and geomorphological analyses and valuation of deltaic coastal Karavasta system in the Adriatic Sea are based on examination of archival documentation and field surveys data.

1. Introduction

Karavasta is the biggest and the most important lagoon system on the Albanian coastal area. It is located on the western lowland, between the mouths of Shkumbini river (in the north) and Seman river (in the South) and is boarded by the Adriatic Sea in the west and by the western of Divjaka Hills in the coast (Fig. 1).

The Karavasta lagoon is of an enormous international importance for its biodiversity and natural productivity.

The Karavasta lagoon has a surface of 43,3 $km^{2,}$ with a maximal length of 10.6 km, a maximal width of 4,3 km and a maximal depth of 1.5m. A component part of this lagoon is another small lagoon named "Godulla". That has a surface of 8.5 km2 with a length of 5 km, a width of 3.8 km and a maximum depth of 3.8 m. The lagoon has a general direction from north to south. It communicates with the Adriatic Sea through three short channels: the North Channel is 900m long, 17 m wide and 0.40m depth. The central channel is 1200 m long, 26m wide and 1.55m depths. The Southern Channel is 300 m long by 23 m wide and 0.61m depth. Through these channels a water exchange process is realized.

The Seman river has a catchment basin of 5649 km2 with an average height of 863m. The average water discharge is 96 m3/s.

The Shkumbini river has a catchment basin of 2440 km2 with an average height of 753m. The average water discharge is 62 m3/s.

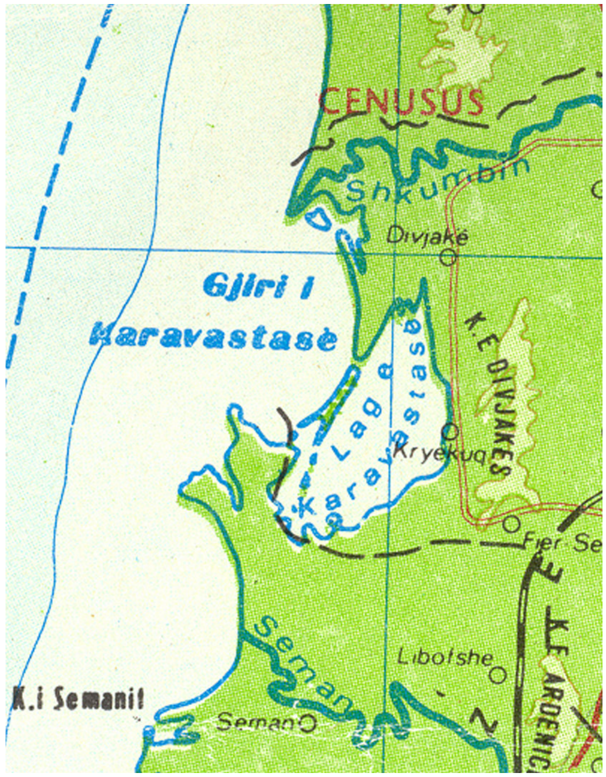


Fig. 1. Karavasta area

View of Karavasta Lagoon

2) **Materials and methods.**

The geological analyses are based on examination of archival documentation and onshore and offshore geological and geophysical (seismic and geoelectrical soundings and profiling) surveying data.

Several physical-chemical parameters have been measured either in situ and in laboratory. In such measurements: water velocity and discharge of the channels from Karavasta Lagoon with Adriatic Sea, water temperatures, salinity, dissolvent oxygen, pH. etc. Hydromorphology regime of deltaic coastal Karavasta system is analyzed based on the examination of cartographical documentation and satellite images (period from 1870 – 2001). The following area analyzed month regimes, wave refraction, marine currents, sediments contribution, coastal sediment sources, dynamic of solid material deposition along the coastal zone, the erosion and accumulation process, the river mouth migration etc.

The hydrological parameters are determined by the multi annual archival data (n=35). The Evatranspiration Potential – Ep haas been calculated by the methods Penman, Turc and Thorthwait and Real Evatranspiration by the method of Thornthwait, Contagne, Kostandinov. The evotranspiration deficit is calculated as a difference ΔE=(Ep-Ep). The evaporation of the lagoon water surfaces is calculated by Bratislavski-Vakunin method.

The component elements of the climatic regime of the area such as precipitation, air temperatures, wind, etc are treated in the first part of the paper. Evaluation of climatic parameters, helps the hydrological calculation of the study. The principal component elements of the hydrological regime: levels, water temperatures, waving, solid discharge are treated in the second part.

The co-operation scale between the air direction force on the sea surface and the hydromorphometric characteristics mainly determines, waving regime. Considering topohydrographical parameters of Eastern Mediterranean for the wind "running" L=1200 – 2000 km, and the respective technical information for historical maximal waves on the open sea, the calculated maximal wave with p=1% probably is accepted the wave with height H=8-9m.

The reduction coefficient of the maximal wave passing from the open sea into the coastal area is accepted ŋ = 0.75 for the depth Z_3= -15 m, ŋ = 0.75 for the depth Z_2 = -10m and ŋ = 0.55 for the depth Z_3 = -5m.

The different parameters of the annual water discharges – Qo (in m3/sec), and annual suspend load discharges –Ro (in Kg/s), probably distribution for Seman and Shkumbini river systems are determined. The dynamics of the change of the coastline in its mouth is also determined by variation of the suspended load discharge impact of these rivers in the Adriatic Sea during the multi-annual cycle. (p=1 – 99%).

The erosion process under the wave action and under marine correct is determined. The wave refraction in the coastal area are analyses by wave refraction diagrams. The construction of wave refraction diagrams is carried out by solving partial differential equations, or by solving systems of equations:

$$\left\{ \begin{aligned} &\frac{d\theta}{dy} = \frac{1}{C}\left(\frac{\partial C}{\partial x} - ctg\theta \cdot \frac{\partial C}{\partial y}\right) \\ &\frac{dx}{dy} = C \cdot tg\theta \end{aligned} \right\} \qquad (1)$$

Where: $\theta(x, y)$ - is the angle between the x axis and the tangent of the wave rays at point M(x,y).

C(x,y) – is the wave speed and the same point

(x,y) - is the coordinates of the region.

There are used numerical methods to solve above equation system, so $C = \frac{c}{c_o}$, $\varphi(x, y, \theta) = \frac{1}{C}\left(\frac{\partial C}{\partial x} - ctg\theta \cdot \frac{\partial C}{\partial y}\right)$, then the equation system (1) taken form:

$$\left\{\begin{matrix} \frac{d\theta}{dy} = \varphi(x, y, \theta) \\ \frac{dx}{dy} = ctg \end{matrix}\right\} \qquad (2)$$

The effect of wave energy in shallow water is considered important for the happened along the coast.

The marin current analyses are based on examination of the filed surveys data and oceanological calculation. The oceanological calculations are realized by dynamic method. This method based on formula:

$$u(z) - u(H) = \frac{10\Delta D}{2\varpi h \sin\alpha} \qquad (3)$$

Where: u(z) – the current speed in the sea surface (z=0)

u(H) – the current speed in the calculate surface

ΔH - the difference of the dynamic altitude

w - the vector of the speed

L - distance from two hydrological stations

α - geographical altitude

3) Analyses of the results

a) **Limnology.** In the deltaic coastal of Karavasta area, the Potential Evotranspiration is E=1050 mm, the Real Evotyransporation is E=720 mm and the Evotranspiration Deficit is DP=(Ep-Ep) = 330mm. The annual precipitation rate is about 870 mm, with its minimum in July (25mm) and maximum in October (145 mm). A layer of water with an annual average about 1100 mm evaporated in this lagoon, with its maximum in July (180 mm) and minimum in January (20 mm) (Fig. 2).

The precipitation, evaporation and principal channels of communication mostly determine the water balance of the lagoon of Karavasta. A water-exchange process between Karavasta lagoon and Adriatic Sea with an average discharge of 13-35m^3/s is realized through the channels.

The limited capacity of the communication channels with the sea and the small volumes of the water in the water-exchange process makes it possible that the "incursion" of the high tide in this lagoon is limited and distributed only in narrow-water zone that are is situated round the communication channels with the sea. In these conditions the water exchange process between the Adriatic sea and the lagoon of Karavasta can not circulated the whole volume of the water of this lagoon, but only a small part of it. This is shown in the great heterogeneous geographcal distribution of the physical- chemical characteristic.

The highest values in water salinity inside the lagoon are observed in summer because of the market evaporation rate. The maximum observed values are in excess of 45-55$\%_0$ in the eastern part of the lagoon. The minimum salinity values about 20 - 30 ‰ are observed in winter in the western part of the lagoon, where the tidal influence is weaker.

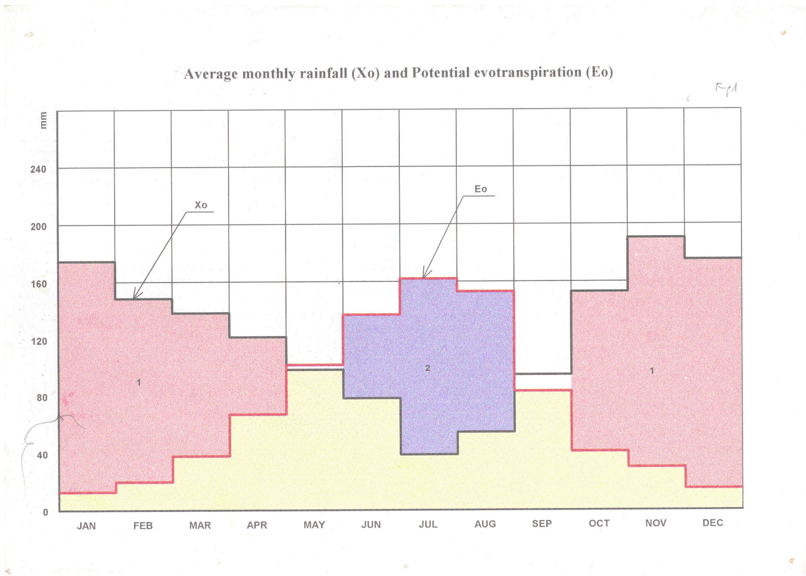
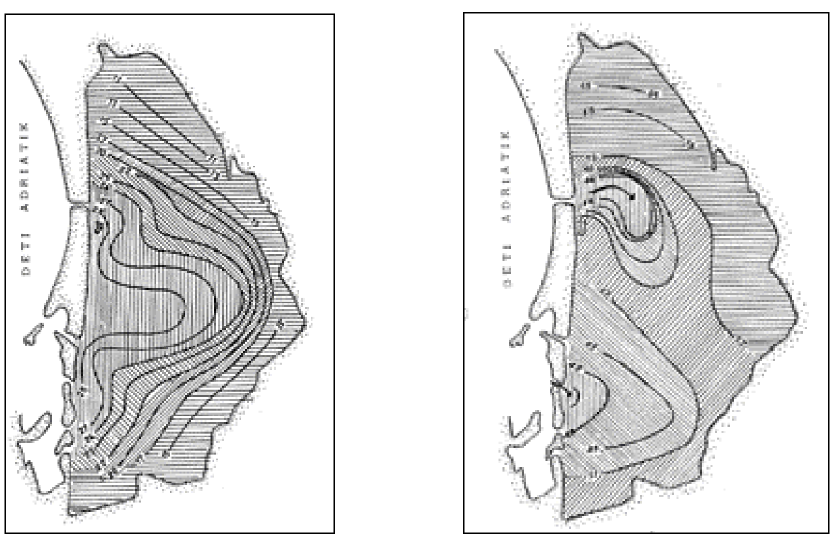


Fig. 2.

Salinity distribution in the lagoon is presented in fig. 3.

Dissolved oxygen concentration in water as well as other physical and chemical factors range widely in space and time. The lowest values correspond to the driest period (6.0-9.5 mg/l), the highest on to the wettest and coldest period (11.30-12.75mg/l) (Fig. 4) (Pano N. et al. 1982)

pH of the lagoon water depends on the concentration of the bicarbonate and the carbonate ions, and dissolved carbonic gaze. In general pH oscillates from 7.5 to 8.9).



a b

Fig. 3. Salinity diustribution in Karavasta Lagoon waters

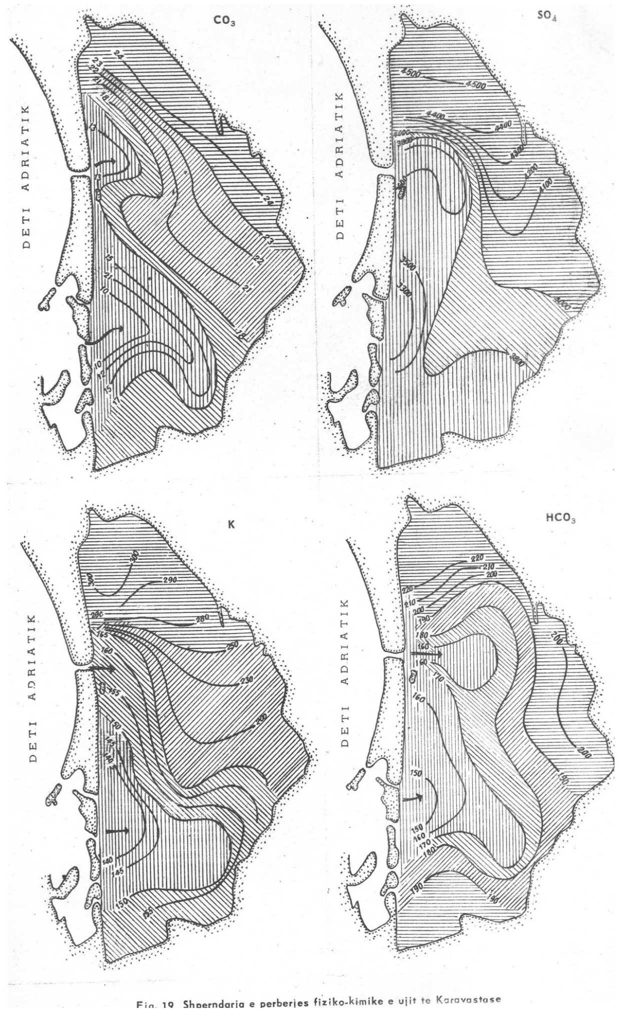


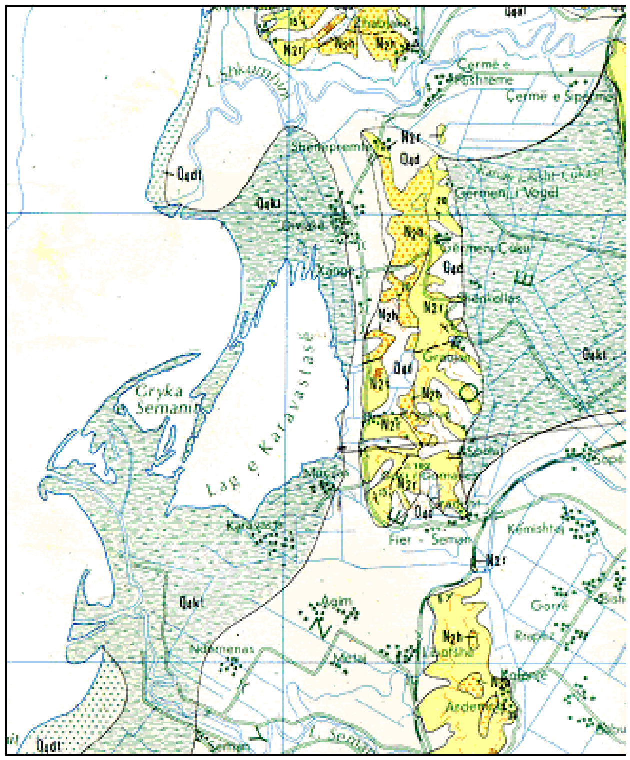
Fig. 4. Physical-Chemical Water Characteristics

b) Outlook on area geology: Albanian Adriatic Littoral area is located in Albanian Sedimentary Basin, which extends widely into the Adriatic Sea (Aliaj Sh. 1989, Frasheri A. 1994, Frasheri et al. 1977, 1991, 1995). Albanian Sedimentary Basin represents a foredeep depression filled with Miocene and Pliocene molasses, and covered by Quaternary deposits (Fig. 5) (Frasheri et al. 1977, Papa A. 1985). Karavasta lagoon is located on western flank of the Miocene Divjaka brachyanticline. Pliocene molasses are outcropped in the top of the structure, which extended at the east direction from lagoon.

The Pliocene molasses are covered by Quaternary deposits in the Karavasta lagoon and plane coastal area around. Quaternary deposit (Q) are represented by different genetic types: marine deposits which have a thickness up to 200 meters in the Adriatic littoral areas, lagoon's and coastal marsh deposits, and alluvial deposits - clayey earth (Frasheri A. et al 1991, 1994, Leci V. et al. 1986, Ostrosi 1968, Sinoimeri Z. 1966, Thereska J. 1981). In the accumulation coast the width of sandy belt reaches up to 5 km. The flat shelf sinks gradually up to the depth 100m. Up to this depth the majority of deposits represents by sand and silt. Marine deep erosion is developed in accumulation littoral of Adriatic shoal. The sandstone banks have been mapped in western submarine anticline limbs. The coastline between

Karavasta and Narta lagoons has beautiful sandy beach. Sand dunes are situated along the sandy littoral belt. Dunes belt has a length of 25 km and an average width of 50-100 m. Generally, the granulometry of quartzite sand deposits represented by: very fine sand (□□0.1 mm) 6.43%, fine sand (□=0.1-0.4 mm) 88.15%, medium sand (□= 0.4-1.25 mm) 4.66% and coarse sand (□= 1.25%) 0.76%. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom.

The lagoons have a neotectonic origin. They were created during the closing of old marine bays by sandy belts. The Karavasta lagoon is one of the youngest natural water objects in the hydrographical network of Albania. It is formed during the last centuries as results of



Legend

Q_{4dt} - Marine Quaternary Deposits
Q_{4kt} - Swamp's Quaternary Deposits
Q_{4al} - Alluvial Quaternary Deposits
Q_{4d} - Delluvial Quaternary Deposits
N_{2r} - Pliocene Rrogozhina Suite (Conglomerate)
N_{2h} - Pliocene Helmesi Suite (Clay)

Fig. 5. Geological Map of Karavasta area

the accumulation of solid discharge of Semani and Shkumbini Rivers. Once upon a time part of Adriatic and Ionian gulfs; have been separated with sea by Quaternary deposits (Luli N. 1964). The lagoons represent the new lakes. Its creation started during Pliocene Period, some 4-5 million years ago, and its creation lasted during the Quaternary Era till our days.

c) The geomorphology. Karavasta lagoon is one of the youngest natural water objects in the hydrographical network of Albania. It is formed during the last period as a result of the solid discharge accumulation of Seman and Shkumbini rivers.

Hydromorphology of the deltaic coastal Karavasta area is mainly determined by the cooperation scale between the winds and waving regime, sea currents, sediment discharges etc.

The winds in the Adriatic Sea change their direction and speed during a year period as a result of the typical Mediterranean climate. This characteristic is mainly determined by a passing trajectory of basic systems over Mediterranean sea and Balkanic peninsula as well as other important factors such as morphometric characteristics of the territory, etc.

Intensive winds with their maximal speed of 40 – 45m/s particular of NW,W and SW direction are observed in the coastal area. It must be stressed that duration of high speed winds in the coastal area is short, so their influence on the wave regime is small. Winds with varying speed form 10 to 20 m/s, a bigger frequency on waving process. In these conditions the wind speed V=20m/s is chosen to value the calculating maximal waves.

The waving regime is mainly determined by the co-operation scale between the direction force on the sea surface and the hydromorphometric characteristics of the area. Maximal waves frequency according to their principal directions with their corresponding heights are calculated at the same time. The period with the wave height H_1 = 0,1-0,2m represents about 80% of the general cases, while the height H=0.2-4.5 m about 2o% of them for the average multi annual year.

Wave running direction in the deltaic coastal Karavasta area is SW direction about 33% of general cases, W direction 30% and NW direction 29%.

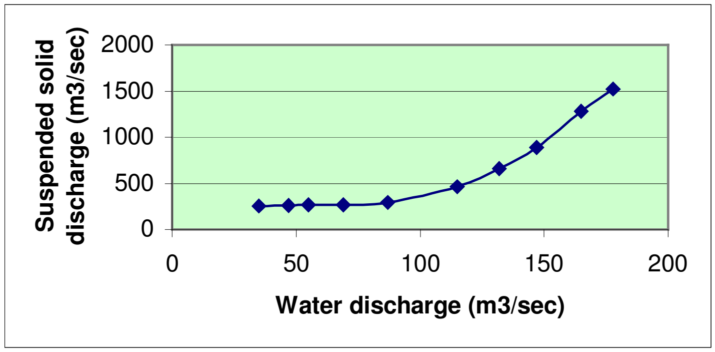
The treatment of actual statistical information indicated that the respective parameters of the height stormy with p=1% probability are the height H1=3.20-4.50m, the length L = 60 – 85m, the period T = 20 30 hours, the velocity C=6-8m/s and formation wave time T=20-30 hours.. These parameters are referred to the relatively defended coastal area with the depth about Z= -10 to -5 m.

The trajectory of waves refraction in the coastal area has respectively SW, W and NW – general directions.

The trajectory of the main current in the coastal area has a N general direction with average speed: from 0.10 to 0.60 m/s. and the maximal speed: V=0.08:-1.10 m/s.

The Seman and Shkumbini rivers are the main source of coastal sediments in Karavasta bay. .

The geomorpholocigal regime of the Seman river mouth in the Adriatic Sea has been analyzed based on the examination of cartographical documentation (from following sources: Austro-Hungarian Institute of Cartographic 1870, at the scale: 1:100 000, Military Italian Geograpgic Institute of Cartography 1918 and 1938.to the scale 1: 250 000 and 1:50 000. respectively, Soviet Naval Institute of Cartography 1955 at the scale : 1 : 100 000, Albanian Hydrometerological Institute 1978 and 1988, at the scale 1:5000, landsat. Satellite imagery: 1975, 1982, 1994 and 2001), on the determining sources of the sediments, the littoral sediments transport and coastal sedimentation, on classifying of the erosion and accumulation processes by means of wave refraction. The dynamic of the change of the coast line in the Seman and Shkumbini River mouths is also determined by variation of the impact of the suspended load discharge of this river in the Adriatic Sea are W_t=23.720^6 tones/year. From this about 20% of total sediment load is equivalent to W_t=4,75120^6 tones/year is carried bat load and the other is 80% of total sediment load equivalent to W_t=19.010^6 tones/year. is suspended sediments (Fig. 6).(Pano N. 1984)..



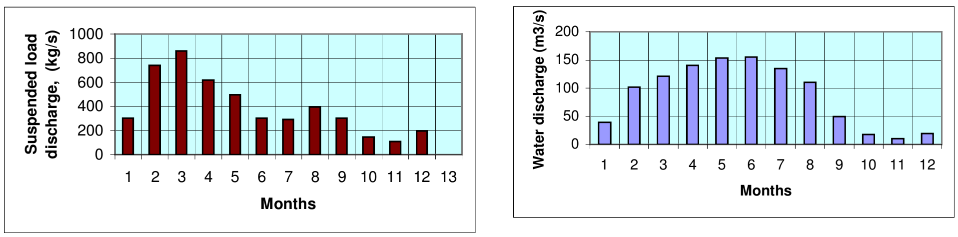


Fig. 6. Long term monthly distribution of the suspended load discharge and water of the Semani River. in the Adriatic Sea.

Many coastal transformations have taken place due to the modifications caused by river bad migration, with abandonment of all channels following, a decreased discharged or creation of new river mouths. In this conditions in the coast area there are two important sources of coastal sediments (Fig. 7,8,9):

1) The actual rivers mouth and
2) The olds rivers mouths.

The olds mouths of this river have been undergoing on important erosion process under the wave action and marine currents.

The outlet of Semani River was shifted from position A and A1, the old mouths, to the actual position B", that is up date position. The old mouths of this river (coastal area A' and coast A") is undergoing on important erosion process under the wave action. So there are important sources of coastal sediments in the coastline are: Firstly, the present Semani River mouth >1962-1963 years and secondly, the two old Semani River mouths.

The dynamic of solid material deposition along the coastal zone and the accumulation intensity of sand are closely tied up with the waving process and particularly with the effects of maximum waves. This coastline corresponds to an extensive deltaic coast (microtidale: 0.50 tidal range) with a ;large alluvial plain of Myzeqe, many coastal; lagoons (including the Karavasta Lagoon), temporary marches, deltas, offshore bards, sand dunes and sandy beaches (Simeoni U. et al, 1997).

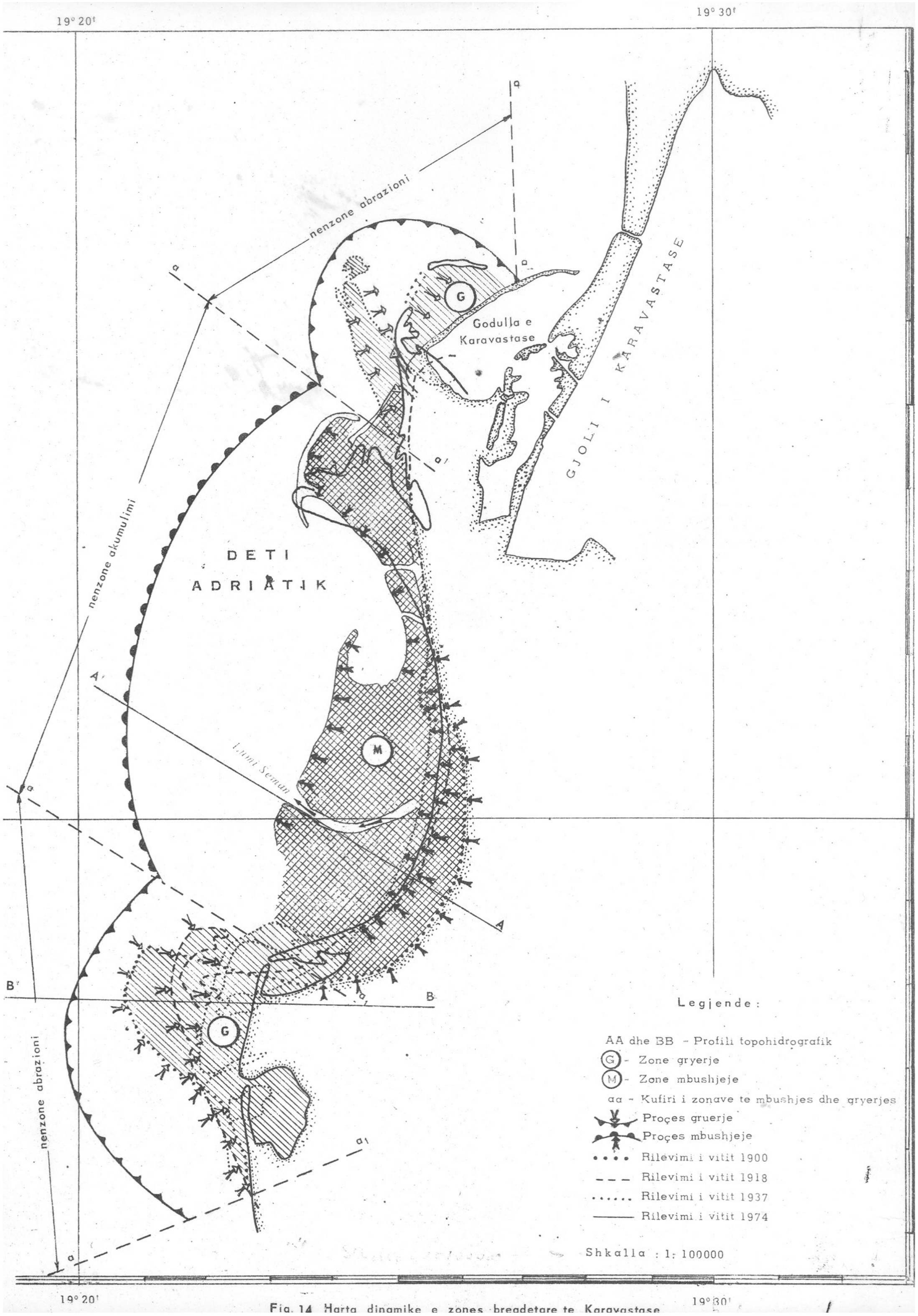


Fig. 7. Coastal hydromorphological classsification

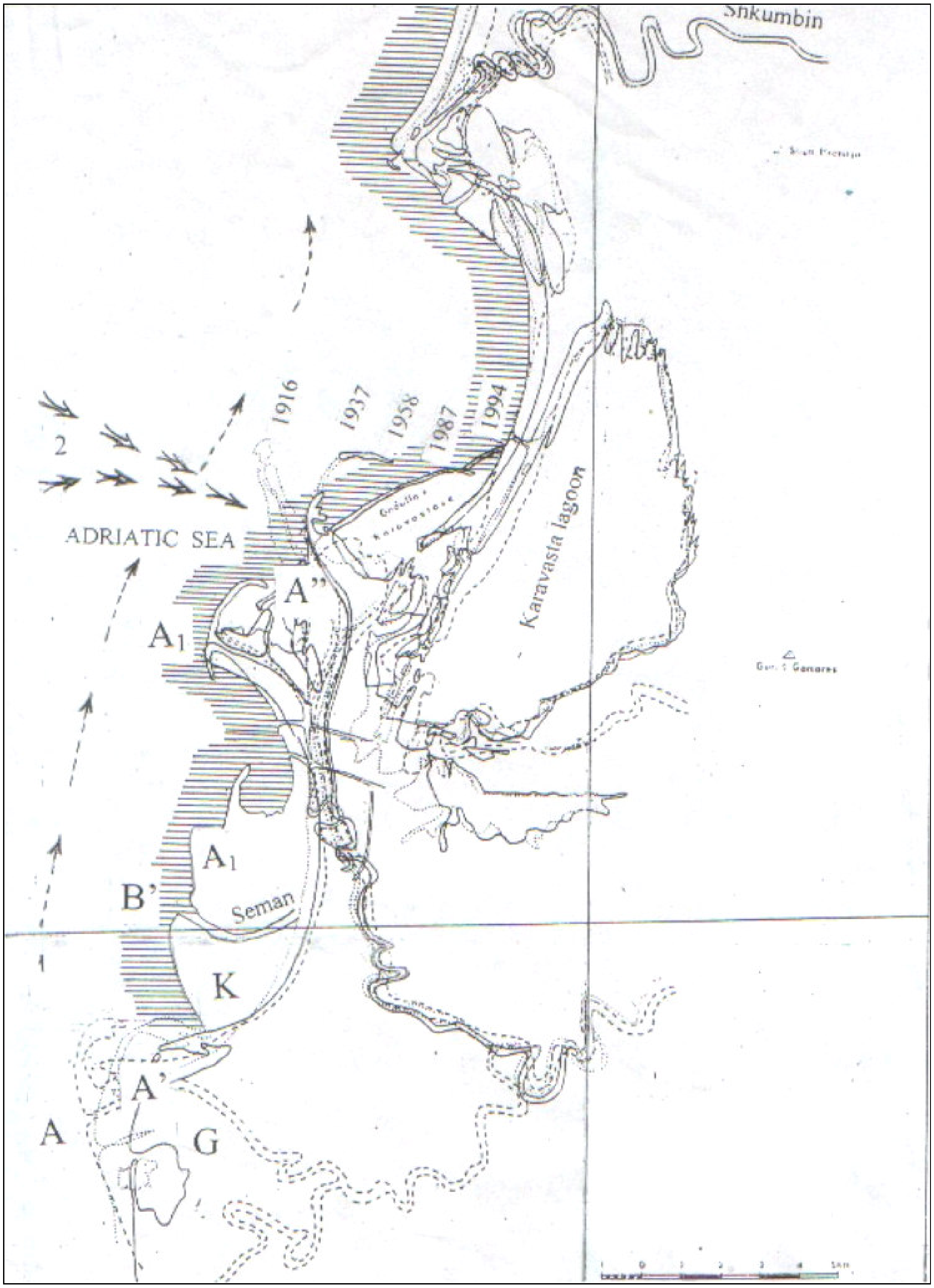


Fig. 8. The general map of the evaluation of the coastline from 1870 to 1994 in the Karavasta area (A and A1 – old river mouths; B' – actual river mouths; A A' A'' – sources of coastal sediments; 1 – marine currents; 2 – wave processes; G – erosion processes; K – accumulation processes)

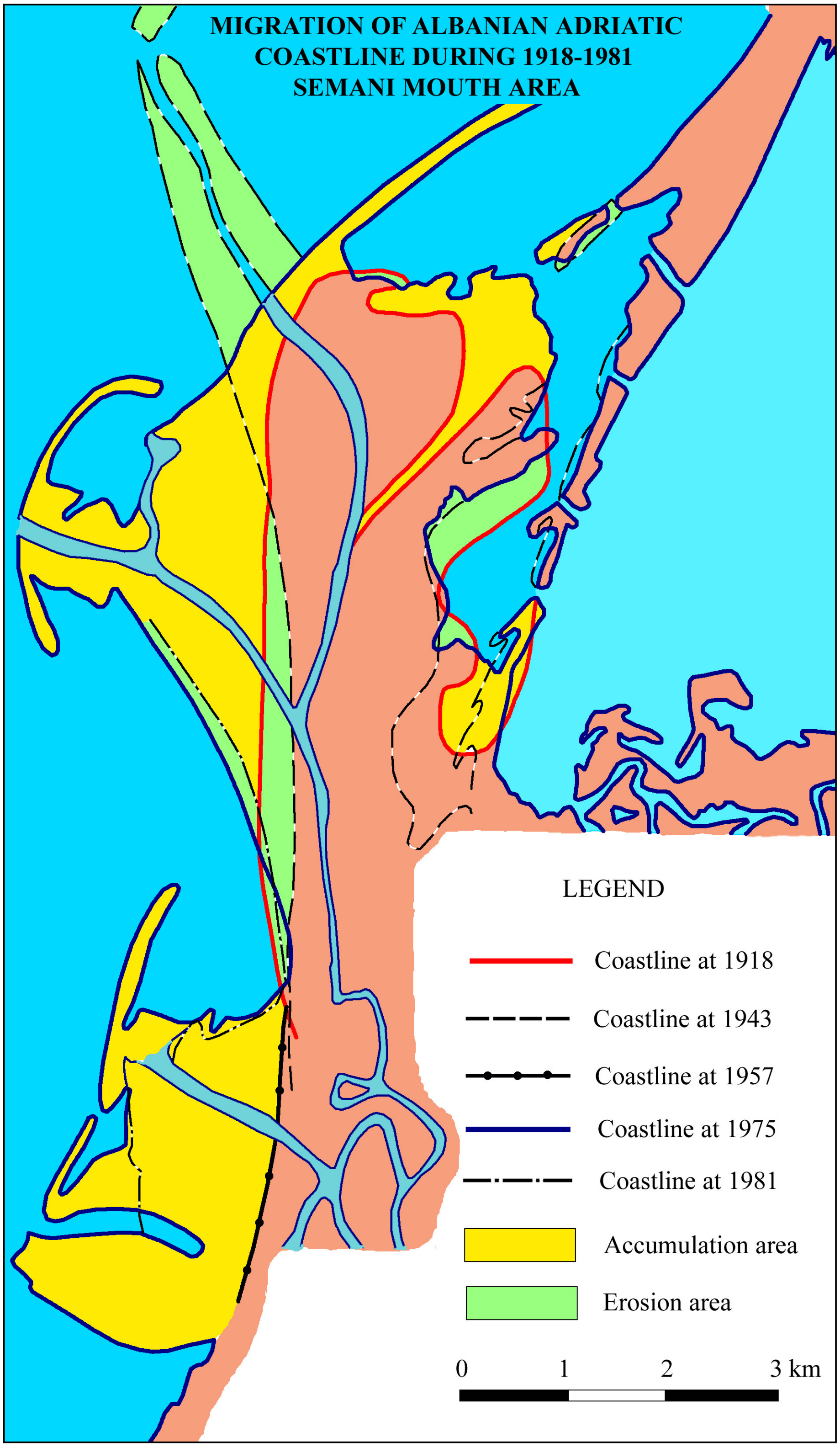

MIGRATION OF ALBANIAN ADRIATIC
COASTLINE DURING 1918-1981
SEMANI MOUTH AREA
LEGEND
Coastline at 1918
Coastline at 1943
Coastline at 1957
Coastline at 1975
Coastline at 1981
Accumulation area
Erosion area
0
1
2
3 km

Fig. 9.

d) Paleoclimate Change. Beings situated on the Adriatic and Ionian coast it is influenced by the Mediterranean climate of hot and dry summers, and mild winters with abundant rainfall.

In several boreholes at Albanian coastal plane area is observed a decreasing of the geothermal gradient in near surface part of geological section, I the comparison with normal gradient values. This difference presents climate change influence. Generally, during the first half of XX century, the climate worming for about $1^{o}C$ is observed. Thirty quart of this century has been characterized by a cooling for 0.6oC. Later, up to present a worming for $1.2^{O}C$ is observed. Climate change process and Heat Ground History are different not only at plane or mountainous country regions. There are observed difference and between plane regions, depending from the deforestations and situation of the swamps in the coastal areas. This temperature augmentation represents part of the global warming, which is observed at the present in out Planet. Worming period in Albania is accompanied and with changes of the rainfall and wind sped regimes. There is observed decreasing of the annual rainfall quantity for about 200-400 mm. These climate changes have their impact on area forestry, country water system and on Adriatic Sea hydrography (Frashëri A., 2001, Frashëri A. and Pano N. 2003), and in the erosion processes (Pano N. et al. 2004). Temperature augmentation has started to have its influence in the coastal area forests, also at inside of the country territory. There are observed change of the sort of the trees; are increased such trees which has unless necessity for the water and to ride out the aridity, ex. in Divjaka zone have started installed coniferous trees [Frasheri A. etj. 2004, Hasko H. 2003]. Diminution of the forest's surface is another impact of this global warming.

e) Environmental impact. The human activity and climate change impact in this area is intensive.

Agricultural development has often reduced the area of the wetland, and altered the drainage pattern around many important hydrographic areas. Another activity in this area is the chemical plants, oil and gas fields, oil refinery, etc. The anthropogenic activity and the lack of the water treatment has made it possible for the agriculture, industrial and urban pollution to have a negative influence in the ecological balance of the Karavasta lagoon system. A regular monitoring of this system should be established.

The impact of climate change in the limniological and hydromorpbhology regimes in deltaic coastal Karavasta system is intensive.

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